Review of Literature
REVIEW OF LITERATURE

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Health and Nutrition are so interwined that they are almost synonymous. Women enter adulthood already bearing obvious evidence of deprivation and the scars of undernutrition in childhood, namely stunting. To be a healthy woman, there must be a strong foundation of good nutrition from childhood. Infact, this goes even further back into foetal development. Weight and length at birth can be a predictor of her growth potential. This sequel is particularly crucial for young girls who are the potential mothers. The very birth event is dependent on the nutrition of young women, even before conception.

Health and Nutritional Status of Women

During the last 40 years, there have been some impressive gains with respect to women's health. Life expectancy at birth for the female in the country, which stood at 31.7 in 1950, rose to 54.7 in 1980. Female infant mortality had declined to 97 (1986) and female child mortality (0-4 years) to 38.6 (1986). But while more women are thus surviving there is unfortunately not much evidence of substantial improvement in the health and nutritional status of the survivors. The hallmark of poor maternal nutrition and poor antenatal care in a community is the high proportion of babies born with low birth weights - less than 2.5 kg (small for gestational age) (Gopalan, 1989).

Women in Indian society are traditionally the providers of nutrition within the household, and are also affected by malnutrition. "Socio economic" and "Socio cultural" dimensions of the subject of "women and nutrition" have two fold significance. First, cultural norms and practices and socio-economic situations determine the extent to which women are able to affect the nutrition of the household at large; and second, they play roles in determining women's own nutritional status (Chatterjee, 1989).
Micro level studies find higher rates of malnutrition among girls and women than among boys and men in the same age groups. Discrimination against females in matter of feeding already has visible effects on nutritional status during infancy, and these effects persist through childhood. Studies have also documented deterioration in the nutritional status as females grow older, the combined result of socio-cultural, economic and biological processes.

Socio-economic, socio-cultural and biological factors influencing female nutritional status have been summarized in Fig. 1.

Socio-politico-economic factors together with scientific and technological advances have contributed to a phenomenal rise in the material standards of living in the affluent countries of the world in which grim poverty affecting large segments of the population is a thing of the past. In the so called developing countries, however, an appreciable proportion of the population continues to live at or below subsistence levels.

The nutritional requirements for girls and boys are the same. But in some cultures, more girls suffer from severe malnutrition and even die. Boys are given preferential feeding as they are expected to be stronger. This cultural attitude dominates other spheres in child health (Chatterjee, 1989).

Ren-Ying Yan (1990) is also of the opinion that girls face discrimination. They are more likely to be malnourished than their brothers and less likely to attend primary school. Girls are also less likely to be taken for medical care when they are ill. According to him in Bangladesh, girls under five receive less food than boys.

Figueroa et al (1988) studied the nutritional and health status of the Latin American women and reported that people from the low socio-economic levels are affected by undernutrition and its associated pathology. It is also reported in
Fig. 1 Socio economic, socio cultural and biological factors influencing female nutritional status.
the study that undernutrition occurs fundamentally among the age groups at higher risk in the population segments with low income, low food intake, illiteracy and poor access to health care and preventive medicine centres. Among families exposed to undernutrition, women are usually in worse condition than men. This the author reported was due to long working hours and the increased nutritional requirements caused by frequent gestations and prolonged lactation.

Women of child bearing age are at greater nutritional risk than other population groups owing to the added demands of reproduction. The mother’s poor nutritional status during pregnancy and delivery impair her future and her ability to perform the many tasks which are her normal responsibility. It also affects the health and development of her child as shown in (Fig. 1) by Mathai (1989).

The girl child whose growth is retarded in utero and early years of life, arrives to the stage of motherhood in poor nutritional status as shown in Fig. 2 (Mathai, 1989).

Vicious cycle: A handicap even at birth in terms of a small body size and poor stores of nutrients, severe growth retardation and malnutrition during the post weaning period, results in continued growth retardation till adolescence, a stunted physical stature and poor productivity as adults, and the effects of all this on the reproductive performance of women (Rajalakshmi, 1980).

Women at risk: Computation of available growth data, indicates that nearly 24 percent of adult women in the reproductive period have body weights less than 38 kg. and 16 percent have heights less than 145 cms. These women according to WHO fall into the high risk category, i.e. they are likely to suffer obstetric complications and give birth to offspring of low birth weight (Gopalan, 1989). Hytten (1980), claims that the belief widely held by nutritionists that the foetus is
Nutritional status of women of child bearing age

Nutrition status at puberty

Girl's nutritional status

Neonatal and Infant nutritional status

Nutritional status of lactating women

Nutritional status of pregnant women

Fig. 2: Cyclical Influences of Maternal Nutritional Status.

vulnerable to maternal dietary inadequacy in pregnancy may be mistaken. It contrasts strikingly with the evidence that child bearing is notably successful in the conditions of chronic maternal undernutrition and that severe dietary restriction may do little more than reduce birth weight without obviously affecting linear growth or postnatal development.

It is therefore possibly assumed that the process of childbearing have evolved in conditions which often must have been unfavorable and physiological mechanisms have developed to protect the foetus from vagaries of maternal food supply.

**Nutrition and Puberty**

Puberty is one phase in a process of neuro-endocrine maturation which begins in the early foetal life and continues through adolescence to adulthood. It is not an event, but a logical sequence of maturational processes that eventually produce reproductive function. Not surprisingly this process can be influenced by external factors, one of the important factor is the level of nutrition.

Moerman (1982) has presented the data on the growth and development of the birth canal and pelvis among healthy teenage girls and reported the mean pelvic size to be well below mean adult pelvic size at age 18. Pelvic dimensions were significantly smaller than adult size for menarcheal age (P<0.01). He also presented data on the size differences between girls with early menarche versus girls with late menarche for each menarcheal age and at age 18. When matched for gynaecologic development, early maturing girls were younger, and also smaller than late maturing girls in cell dimensions of body size and of the birth canal. The author also showed that maturation of the reproductive system and attainment of adult size in stature do not indicate completed growth of the pelvic birth canal. The author concludes that the smaller pelvic capacity which was evident in his sample
of adolescent girls indicated that immaturity of the pelvic basin contributed significantly to the higher incidences of cephalopelvic disproportion and other dystocias during labour observed for primiparous girls below the age of 15.

The clinical impact of disordered nutrition on puberty is obvious, but the mechanism by which this effect is achieved is less clear. Childhood undernutrition delays sexual development in association with a general slowing of growth and maturation. In obese children, neuro-endocrine maturation may be accelerated but this effect may be offset somewhat by reduced gonadal responsiveness to gonadotropic stimulation. It is also suggested that timing of puberty might be related to the acquisition of some critical weight or percentage body fat. It has also been postulated that pubertal adipose tissue is directly involved in the programming of adolescent maturation through its ability to metabolize sex steroids and thus influence the production of estrogens. This hypothesis has found little experimental support. However, most endocrinologists would suggest instead that sexual maturation and body fat accumulation are parallel but unrelated processes, both of which are influenced by nutrition and growth rate (Glass and Swerdloff, 1980).

The onset of menstruation is believed to be related to body size (Frisch, 1980) i.e. a particular ratio of fat to lean mass and total body weight is necessary for puberty. Delayed puberty or secondary amenorrhea has been observed in female athletes and ballet dancers, suggesting that not only the level of food intake but also other factors such as physical activity and competition may influence reproductive function (Frisch et al, 1980).

Since adult female body size has increased during the past two decades, the possibility of a lowered age of menarche was investigated. It is generally believed that the age at menarche is delayed in the rural undernourished and poor populations. With the advancement of industrialization, education and lifestyle in
the western countries, there has been a continuing decline in the age at menarche over the last one century. Since there are no large scale studies to document secular trends in the age at menarche, it is difficult to say categorically whether there has been a lowering of the age at menarche in India. Moreover results of various studies on the subject of menarche from different parts of the country do not represent the true picture because of vast climatic, cultural, socio-economic variations as well as sampling methodologies adopted in these studies. However, based on the available data, there does seem to be a trend towards a decrease in the age at menarche over the decades both in the rural and urban situations, not only in the affluent upper classes but also among the poor classes of urban and rural communities (Raman, 1990). The age of puberty has been steadily decreasing and the average age at menarche is now 12.5 years, with approximately 13% of the population reaching puberty before age 11. Obviously, this change has increased the proportion of sexually mature adolescents in the population and also has increased the length of time during which an adolescent may conceive before reaching adulthood (Cagas and Riley, 1980).

The decrease in the age at menarche, while indicating an improvement in the socio-economic educational and cultural scenario, has its own disadvantage especially among the poor and rural illiterate population. The governmental mandate raising the age of marriage on one hand and the decreasing trend of menarcheal age on the other hand created many social problems for the adolescents, as in the poor communities, education of the girl has not been given enough importance. While the practice of getting married early would hasten the conception if the menarcheal age occurs early, at the same time, not getting them married at the early age can result in unwanted pregnancies leading to illegal abortions, higher morbidity and mortality (Raman, 1990).

Attainment of menarche is an important event in a girl's life. Adolescence, defined by WHO, as the period between 10 and 19 years of age, is a time when
great physical, emotional and social changes take place in a girl's life. This is an age of transformation, mentally and physically from a girl to a woman is an experience cherished by most young people. In many culture, adolescence is a time when girls are given in marriage, sometime before their first menses. As a social custom, and cultural practice, an adolescent girl enters motherhood and married life when she is neither mature enough to understand the meaning of motherhood, nor is her health good enough to cope lactation. For these young women, pregnancy and child bearing will start before the age of 15 when her bones are not well developed to take the strain of pregnancy (Raman, 1990).

Adolescent Period

Growth

Adolescence in contrast to puberty is not a single age or stage but a range of years (13-18) during which an individual develops from a child to an adult. In addition to the enormous amount of physical growth and development that occurs during these years, adolescents experience psychological and social changes.

The growth rate during adolescence is greater than any other time of postnatal life except for the first year of life. At the end of the five year adolescent period the gain in weight in both sexes is 65% of initial weight or 40% of final weight. Height gains account for approximately 15% of adult height. This phenomenal growth requires a great increase in nutrient intake and makes the period particularly vulnerable for nutritional imbalances (Brasel, 1982).

Just after 10 years, the average girl enters the adolescent growth spurt and the growth rate rises to reach a peak and then falls to zero as growth ceases because of fusion of the epiphyseal centers. The age of peak height velocity varies from 10.2 years for early maturers to 13.8 years for late maturers, with the
average age being 12 years. The onset of growth spurt is 8 years for early maturers, 11.5 years for late maturers and 10 years on an average. At the peak, the height gained ranges from 3 to 3.5 inches per year on an average but can be as great as 4.4 inches for rapidly growing early maturer to as little as 2.2 inches for slow growing late maturer. In the 5 years of adolescence, that is from 10 to 15 years, the average girl grows 9.25 inches and gains 46 pounds. During adolescence, girls deposit relatively more total body fat and subcutaneous fat, as measured by skinfold thickness. The rate of increase in subcutaneous is steeper after 13 years, the approximate age of the first menstrual period (Brasel, 1982).

Nutritional status prior to puberty as it affects overall growth is important. Additionally, it is clear that adequate nutrient intake is necessary if the growth associated with puberty is to be accomplished. It is possible to calculate roughly the approximate caloric value of the tissue deposited. In females, the 5-year adolescent growth consists of 9 kg of fat and 12 kg of lean body mass, with caloric values of 81,000 Calories and 48,000 Calories respectively. Hence it is not surprising that decreased energy availability significantly affects adolescent growth and that achievement of full growth potential during this critical period of development is dependent upon adequate nutrient intake (Brasel, 1982).

Nutritional Requirements

Adolescence is the only period of life after birth in which the velocity of growth accelerates. The dramatic physical changes of the body include increases in height and weight, deposition and redistribution of fat, increased lean body mass and enlargement of many organs, including the sexual components whereby the adolescent can beget or conceive. It is obvious that nutrition is closely related to these physical changes, and, as in infancy, optimal growth. Because menarche is an objective milestone of female adolescent growth, it has been used in
nutritional studies (Daniel, 1982). Many methods have been used to assess growth. Height, weight, skinfold thickness, eruption of specific teeth all contribute to the judging of the state of maturation. The most accurate means of evaluating adolescence is the use of skeletal method.

In the study conducted by Daniel (1982), girls consumed 2500 Calories at 12 years and decreased to 1950 Calories by age 17 years. In the same study, the mean iron intakes of the subjects was 20 mg. and 2.5% were classified as anaemic with a haematocrits and transferrin saturation below 16%.

Various anthropometric parameters and indices used for assessing the nutritional status of girls indicated that despite having attained menarche at early age, a large percentage of rural and urban poor girls have deficit in body weight (below 75% of NCHS standard). The deficit was observed in much greater extent in both body mass index as well as body fat. The deficit was of higher order till the age of 14 years in these girls who have not attained menarche. Irrespective of the income status, B-complex deficiency manifesting as angular stomatitis and glossitis was prevalent in 6-15 % of the girls. Vitamin A deficiency (xerophthalmia) was seen in 6% of slum and rural poor girls whereas it was almost nonexistent in the upper middle class. Overall incidence of anaemia (Hb < 12g %) was around 25% irrespective of urban rural residence status. Iron deficiency showed an increase with increasing age especially in those who had attained menarche. These observations have significant implication in terms of future pregnancies. The marriage and conceptions in these girls take place early. It is also a matter of concern that the declining age at menarche may precipitate in even earlier pregnancies (Raman, 1990). Sarupriya and Mathew (1988) studied the nutritional status of tribal adolescents from a village (Gogunda) in Rajasthan. The study indicated inadequacy in all nutrients (other than protein as compared) to the RDA. The adolescents were lighter and shorter and manifested clinical nutritional
symptoms. The authors recommend immediate attention for nutritional improvement of these tribal adolescents.

Efforts at improving nutritional status of girls in their childhood and adolescence are undoubtedly important and would help to improve their stature and body weight before they become adults and enter the reproductive period (NFI, 1989).

Nutritional deficiency signs get aggravated if the adolescent girl conceives immediately after menarche, since she has to meet the demands of not only her growth, but also that of conceptus. The incidence of pre-eclampsia and eclampsia have been found to be higher and so also the pregnancy wastages. It is felt that congenital defects specially neurotubal defects are more common in the younger age group than in the adult. These girls also have poor weight gain and due to the complications of pregnancy and thus have premature delivery (Raman, 1990).

**Adolescent Mother**

In many parts of the world, both East and West, teenage pregnancies are common. Before these girls have completed their own growth, they have to meet the requirements of the growing foetus as well. Is it small wonder when teenage pregnancies in developing countries invariably result in low birth weight? In some culture, the status of women is such that girls have no choice, they may not be actually forced but indeed they have to acquiesce to the parental decision to marry early. There are countries where 50% of primigravids are below 18 years of age.

The phrase maternal nutrition often tends to be limited to the nutritional requirements of pregnancy and lactation. It is often measured only in terms of the outcome of pregnancy, namely birth weight and lactation performance. Attention
must be expanded to a wider range of needs that would meet the demands of women's multiple roles in maternity. It is also necessary to look at maternal nutrition for woman's own benefit. Child bearing poses many demands on the woman's nutritional status (Rajalakshmi, 1980).

1) She has to meet the extra nutritional needs of pregnancy and lactation, i.e. her own plus those of the foetus or young infant.

2) She has to be in good nutrition for the ordeal of delivery and for the outcome of pregnancy, namely the survival of her baby and successful lactation.

3) The brain growth of the baby would depend on the satisfactory environment she provides as well as the later mental development of the child and the emotional needs she satisfies.

4) Her activity in response to child care would require extra time and energy.

The dietary deficiencies are escalated by food-taboos during pregnancy. Not only beliefs about "hot and cold are restrictive, but certain foods are prescribed for fear of causing skin conditions in the baby: still further, traditional foods are given to 'prevent large babies' so as to facilitate delivery (Rajalakshmi 1980).

The nutritional symbiosis between mother and foetus seems to involve a deliberate change of nutrient levels in the maternal blood to shift the balance of advantage to the foetus.

**Nutritional Needs of the Foetus**

The demands of the foetus for all nutrients are considerably greater towards the end of gestation than in the early months. Growth in size and changing composition make much bigger demands on the mother for some body
constituents than for others in terms of the volume of serum required to supply the necessary quantities each day. The largest volumes of the mother serum are needed to provide the foetus with its requirements of energy in the form of glucose, specific amino acids, calcium and phosphorous. When the mother's cardiac output and flow of blood to the foetus are low because she is small or undernourished, it will be the supply of one or all of these nutrients that will limit growth (Southgate & Hey, 1976).

Weight and length at birth in a small for date baby can be a predictor of her growth potential. Whereas pre-term low birth weight babies can and do overcome their handicap. Infact, correct feeding, guided by knowledge of nutritional requirements, would reverse this situation. Intra-uterine growth retardation, however dominates throughout life.

During the first six months of gestation the foetal body contains very little fat. Fatty acids essential for the phospholipids of the developing brain, nervous system and cell membranes cross the placenta from the mother's circulation, but deposition of triglycerides in the cells of adipose tissue does not begin until the foetus starts to synthesize fat from glucose at about 26 weeks gestation. The amount of fat in the body then rises rapidly, most of it being deposited in the subcutaneous tissue, and at term 80% of the fat in the body is in this site.

The foetuses that were small for gestational age have less fat than the larger ones because they were smaller but per 100g of body the fat was the same. Placental transfer of fatty acids continuous throughout gestation, but quantitatively foetal synthesis becomes more important. During the last four weeks probably only 1-2% of the lipid comes from the essential fatty acids in the maternal serum (Southgate and Hey, 1976).
The pattern of depot fat is confirmed by measurements of skinfold thickness which further show the characteristic centripetal distribution of fat accumulation in pregnancy. Over the abdomen, back and upper thighs there is a progressive increase in skinfold thickness up to about 30 weeks after which there is no further change. Over the arms and lower parts of the thighs there is no increase but a loss.

The average woman will enter the last trimester of pregnancy, during which the foetus will almost double its weight, with a considerable buffer against possible food shortage amounting to more than 30,000 Calories (Fig. 4). This figure shows that fat accumulation dominates the overall specific energy cost of pregnancy. It is greatest at a time when the maintenance costs of extra metabolism are relatively slight and stops in late pregnancy when maintenance costs are high, so that it has a smoothening effect on costs, keeping them at a steady increase of 400 Calories per day throughout pregnancy. Moreover, this figure also shows clearly that the energy costs of maintenance could be completely subsidized by the stored fat during late pregnancy. Evidence suggests that the stimulus to accumulate this large extra fat store is not simply through the appetite satiety centres driving the mother to eat more but by a more fundamental change in the control of energy balance, probably caused by progesterone.

Concern about the eating habits of pregnant women is as old as history. In primitive societies there have always been food taboos for pregnant women and there can be few foods which have not somewhere, and at sometime been forbidden. Against that background most nutritionists have held that a plentiful and high quality diet for the mother is essential for the well being of the foetus.
Fig. 3 The components of weight gained in normal pregnancy.
Source: Hytten (1980)

Fig. 4 The cumulative energy cost of pregnancy and its components
Source: Hytten (1980)
There is a rapid rise in the amount of fat, protein and in body weight during the last three months of gestation. The foetus also has some carbohydrate as glucose and glycogen. The protein is synthesized by the foetus from the amino acids from its mother's circulation, and glucose provides it with most of its energy, both for general metabolism and for new body tissue in the form of fat (Southgate and Hey, 1976).

**Nutritional Status of the Mother**

The flow diagram indicates the factors which influence the nutritional status of the adolescent girls. This is more relevant to her pregnancy status, which is thrust on her, because of early marriage (Fig. 5).

Teenage pregnancies differ from those of older women in a number of important respects. Both the conceptus and the placenta are smaller when the mother is a teenager for the same pregnancy weight gain.

One of the more important protective devices is a major modification of the mother's energy balance. The average healthier pregnant woman eating to appetite gains a total of about 12.5 kg. body weight, considerably more than that can be accounted for in the product of conception, the growth of the uterus and breasts and the expansion of blood volume and other body fluids. The extra weight, amounting to 3.5 kg. is depot fat and is accumulated before 30 weeks of pregnancy (Fig. 3). Mother's energy balance changes in early pregnancy so that if food is available she will eat more than usual and lay down depot fat; in a woman eating to appetite, this store will amount to more than 3 kg. and represents an energy bank capable of subsidizing all the extra costs of late pregnancy (Hytten, 1980).
Fig. 5: Factors Influencing Nutritional Status of Adolescent Pregnant Girls.

What is the evidence?

First, there is epidemiological evidence, the fact that still birth and perinatal death rates are higher, and birth weights lower, among women in poor social circumstances. Women who eat a poor diet in adult life have generally eaten a poor diet in childhood and enjoyed less optimum growth. The increase in birth weight due to supplemented diet might be a function of the accumulation of foetal adipose tissue.

A Technical Report Paper (1989) on nutrition management of adolescent pregnancy reported that a high proportion of pregnant teens are nutritionally at risk and require nutrition intervention early and throughout their pregnancies. Although questions remain about continued growth, nutrition needs, and the extent of biological immaturity as risk factors, it is certain that the psychosocial and economic risks to the pregnant women are great at this time. The nutrition needs of the teens can best be met by consumption of foods with a high concentration and balance of nutrients. The recommended weight gain should be achieved and will relate to the maturational stage and the pre-pregnant height for weight proportion. As an integral part of the health care programmes for pregnant teenagers, the nutrition consultant must be skillful in establishing rapport and developing a relationship within which to counsel patients in the nutritional aspects which would have lasting effect on the future of the mother and child.

It seems clear that most of these phenomenon are a result of starvation, although in anorexia nervosa additional psychologic factors may perturb hypothalamic function.

Young girls must know about the adolescent growth spurt, the special nutrient requirements to make up for menstrual losses. The reflection of their
ultimate height and weight as being crucial to birth weights and the survival of the future offspring must be revealed to them (Rajalakshmi, 1980).

Pregnancy and child bearing in adolescence - especially at age 16 or younger, carry both health and social risks and also contribute to multiple complications of teenage pregnancies resulting in a vicious cycle of poor reproductive performance and unhealthy and nutritionally inadequate babies.

**Pregnancy Outcome**

With all these background information it is of importance to know also what happens to the pregnancy outcome in adolescent primigravids. The dangers of adolescent pregnancy are known since the time of Sushrutha and Vagbhattas in 300-500 BC who have very clearly described the dangers of conception in a girl before the age of 16. They have emphasized that such pregnancy can end not only in the poor health of the mother, but also poor health of the child and that such children do not survive very long (Raman, 1990).

The reports on the outcome of teenage pregnancies in the literature are equivocal. It is generally felt that the acceleration of growth in adolescents imposes increased demand on nutrients and added stress of pregnancy further raises the needs of the growing foetus. In poor socio-economic class, the lack of availability of food and nutrients and presence of dual stress of growth and pregnancy makes the girl trebly susceptible to aggravation of malnutrition.

**Socio-economic and Educational Status**

Socio-economic status mainly reflects income and living conditions of a population and also it often reflects nutritional status. A significant association of socio-economic status with maternal height/weight, maternal weight gain during
pregnancy and birth weight have been reported. Incidence of low birth weight was found to be high in mothers of poor stature who mostly belonged to the low socio-economic group. (Schneck et al., 1990). Mothers from low socio-economic group were lighter and shorter than those from higher socio-economic group. Their food intake especially the calorie content of the diet was lower than the latter group (Figueroa et al., 1988). Both maternal and perinatal mortality are highest in low income group and lowest in higher socio-economic group. Eighty percent of births are either premature or LBW in the low income group. The incidence of low birth weight decreases with increasing socio-economic status (Annual Report, NIN, 1983- A). Low income pregnant teens are likely to be at dietary risk (Schneck et al., 1990).

Education of the mother plays an important role in rearing and caring for the babies. Educated mothers can take full advantage of available health facilities. Oni (1986) observed a significant relationship between maternal education and birth weight of babies in Nigeria. (Murphy, 1981; ICMR Project Report, 1985-86; Figueroa et al., 1988; Harrison, 1989; Pandey, 1992) reported similar results associating illiteracy with poor obstetric outcome.

Age and Parity

The age of menarche varies considerably in different parts of the world. The mean age at present among the rural girls of the country is 14.0 years (Gopalan, 1989), 12.7 years (Annual Report, NIN, 1985), 12.9 years in U.S.A. (Frisch, 1984), 12.5 years in USA (Rosso, 1990). This is influenced by socio-economic, environmental and other factors like physical activity, nutritional status, etc. besides genetic component. Menarche, assumes significant role because of its relationship with peak velocities for height and weight which ultimately determine the adult status (Tripathi, 1988; Gopalan, 1989).
Early menarche was significantly associated with an increased risk of LBW which was also correlated with earlier pregnancy and child bearing (Garn and Petzold, 1983; Annual Report, NIN, 1985; Gopalan, 1989; Scholl et al, 1989). All the authors are of the opinion that the situation is still unclear concerning the outcome in the low 'gynaecological age' (years since menarche) as an obstetric risk factor.

Among the various prenatal factors which have been identified as affecting birth weight, gestational age is considered as one of the most important (Briend Andre, 1980), especially because it accounts for more than one fifth of the statistical variance in birth weights. However, it is important to note that there are difficulties in estimating the gestational age quite precisely, since the date of the last menstrual period is also quite unreliable. Gestational age has been defined as the length of time, the foetus has been in the uterus. The normal gestational period in humans ranges from 37 to 42 weeks, with a mean of 40 weeks (280 days). Live birth before 37 weeks is considered premature (Carr-Hill, 1985).

Battalgia (1967) proposed a classification of babies into 9 groups based on gestational age and birth weight percentiles (Table 1). This classification has gained wide acceptance and is being routinely used all over the world.

This classification is used to identify babies at high risk: Preterm infants are at higher risk as compared to post term infants who in turn are at higher risk than term neonates. Thus LGA and SGA babies are at higher risk than AGA neonates. The group at highest risk of perinatal complications, morbidity and mortality is the low birth weight preterm and SGA group. Term AGA infants have lowest risk. SGA for small for date (SFD) infants are an obstetric problem. In most cases their condition is less than optimal. The incidence of intra-uterine death, intra-partum hypoxia and handicaps have been reported to be higher in SFD babies (Vanclavinkova, 1988). These conditions occur more often in high risk
mothers i.e. teenagers, mothers with poor pregnancy weight gain and in case of high parity. Saha et al (1983) reported that though the mortality rate was lower in SGA infants, their future growth was slower. On the other hand those preterm low birth weight babies who survived, showed better growth velocity than the SGA infants.

Rush et al (1980) makes a controversial report, regarding the effect of maternal nutrition on length of gestation. He reported that with balanced protein calorie supplements the length of gestation was increased and consequently the proportion of low birth weight infants was reduced. However on high protein supplements a large number of women had early premature deliveries with increased incidence of neonatal deaths.

Kristal and Rush (1984), Scholl et al (1990) in their paper tried to explore the question of whether there was a relationship between maternal nutrition and duration of gestation. They indicated that correlation coefficients between maternal pre- pregnancy weight and duration of gestation were small. The same author also reported that significantly more deliveries were observed at less than 37 weeks' gestation among those who were underweight. A negative but not significant correlation was observed between body mass index with duration of gestation (r=0.07).

A weak but significant correlation of weight at the first clinic visit (at a mean gestational age of 19.4 weeks) was observed with duration of gestation. (r=0.10, P<0.001). However, ideal maternal weight for height was uncorrelated with duration of gestation (r=0.001, NS). They were consistent with a small effect of maternal heights, possibly reflecting nutrition in early life. Although a weak association was found between maternal weight and duration of gestation, none were potential mediating factors.
Table 1: Classification of infants based on gestational age.

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<th>Post term AGA</th>
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<td>42 weeks Post term SGA</td>
<td>Post term AGA</td>
<td>Post term LGA</td>
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<td>37 weeks Term SGA</td>
<td>Term AGA</td>
<td>Term LGA</td>
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<tr>
<td>&lt; 37 weeks Preterm SGA</td>
<td>Preterm AGA</td>
<td>Preterm LGA</td>
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<tr>
<td>Birth weight (Percentile)</td>
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1. SGA Small for gestational age.
2. AGA Appropriate for gestational age.
3. LGA Large for gestational age.

Source: Battaglia (1967).
A few others also studied the maternal undernutrition and duration of gestation. They observed that women of lower socio-economic status eat less. Concomitantly, lower socio-economic status women have infants of lower birth weight, but evidence of shorter duration is inconsistent. The study on both chronic and acute undernutrition are inconclusive and suggested that if there are associations between maternal undernutrition with duration of gestation, they were probably small. Again, the relationship of undernutrition and infant size at birth appeared to be largely independant of reduced gestational age. Similar comment was made by Dougherty and Jones (1982), Horon et al (1983) and Rosso (1990). These authors also reported that associations of maternal fat stores at conception or early pregnancy with infant size can only minimally be due to increased duration of gestation, among women not exposed to severe nutritional stress.

Many researchers have reported a positive correlation between birth weight and a specific range of maternal age. It is well accepted that incidence of low birth weight babies (<=2500 gms.) is much higher in teenage mothers (Horon et al, 1983). The US Department of Health, Education and Welfare reported in 1965 that 18.7% of low birth weight babies were born to mothers under 15 years of age in USA. They also reported that as the maternal age increased, the proportion of low birth weight babies decreased. Lowest rate was reported in the 25-29 years. Similar results have been reported by the following authors (NAS, 1970; Ghai, 1980; Annual Report, NIN, 1982; Ramankutty et al, 1983; Sanghvi, 1983; Zuckerman Barry et al, 1983; Mc Cormick et al, 1984; ICMR report, 1985-86; Friede et al, 1987; Figueroa, 1988; Gomez et al, 1988; Haiek and Lederman, 1988; Lee et al, 1988; Maso et al, 1988; Adedoyen, 1989; Slap and Schwartz, 1989; Beherman et al, 1990; Goranov et al, 1990; Rosso, 1990; Santelli et al, 1990; Stevens et al, 1990; Brown et al, 1991).
These authors have attributed this difference in birth weight to poor socio-demographic and prenatal status of young mothers, (Lee et al 1988, Stevens et al 1990) health and socio characteristics of adolescent mothers (Zuckerman et al 1983), socio-economic disadvantage of young mothers having limited resources to cope with their children's health needs and their potential vulnerability to decreases in public programmes supporting child health care (McCormick et al, 1984). Early pregnancy nausea and vomiting also has been reported to be of the major risk factors for teenage pregnancy because they are likely to be nutritionally stressed (Beherman et al, 1990).

In contrast to the results mentioned above, some of the authors have reported otherwise. (Rothenberg and Vorga, 1981; Loris et al, 1985; Geervani and Jayashree, 1988; Gale et al, 1989) found no differences between infants of teenage and older mothers in terms of prematurity or birth weight. These authors suggest that when relevant background characteristics are controlled, children of teenage mothers are as healthy and develop as well as children of older mothers. Loris et al (1985) suggested that in the case of mothers whose gynaecological age was less than three years at the time of delivery, maternal age and birth weight was correlated. Though Geervani and Jayashree (1988), found no difference between the anthropometric parameters of the infants born to adolescent and adult women. However, they observed that infants of adult women had significantly better growth in weight and height after birth. Gale et al (1989), suggested that in a community that provides extensive social and economic support and good access to prenatal care of high standard, teenage pregnancy need not be a neonatal risk factor.

A major problem of early adolescent pregnancy is that young women are not fully grown. Their pelvic bones develop fully only when they have attained their full stature. This means that there is a danger of obstructed labour, which without appropriate health service intervention is fatal.
The risk of obstetric fistulae, prolonged obstructed labour, premature delivery, caesarian sections due to cephalopelvic disproportion, toxaemia were found to be highest among the teenage primigravidae (Harrison 1989). Similar observations were made by these authors (Refcroft and Kessler, 1980; Murphy, 1981; Sanghvi, 1983; Tahzib, 1983; Harrison, 1985; Ren-Ying Yan, 1990; Rosso, 1990; Ventura and Gresch, 1990; Brown et al, 1991; Jarono et al, 1992). Apart from the above mentioned obstetric outcome, Refcroft and Kessler (1980) also observed increased prevalence of preeclampsia and pelvic inlet contraction in the teenager group. Jarono et al (1992) demonstrated preterm babies more often and a higher rate of congenital abnormalities apart from the obstetric performance mentioned earlier in the teenagers than in older mothers. Harrison (1985) reported hemorrhage and infections also to be higher among the teenagers.

Bradford (1989), Mikulanda et al (1989), Walcher and Petru (1989) found no difference in the obstetric performance between teenagers and adult mothers. On the contrary, they observed significantly shorter labour length and similar rate of pre-eclampsia between the two groups. These authors no longer consider younger aged mothers to be of higher obstetric risk.

However, authors found some disagreement about the reasons for these findings. Whether the unfavourable outcome of pregnancy in the teenage mothers was due solely to their own biological characteristics or to the environmental and social conditions to which she is exposed. Some of the reasons expressed by the authors are improper prenatal care and lack of assistance of a trained attendant during delivery (Refcroft and Kessler, 1980; Sanghvi, 1983; Harrison, 1985; Ren Ying Yan, 1990). Poverty, inadequate nutrition, poor health before pregnancy, physical immaturity, severe deprivation, unfavourable socio-economic status and cigarette smoking have also been associated by these authors for poor obstetric performance among young mothers.
For reasons that are not clearly understood, hypertensive disorders of pregnancy seem to be much more common in young women, especially if they are primiparous. Eclampsia remains a common obstetric emergency among the younger group. It is among the top of those causing maternal mortality.

According to Kapesa (1985), the rate of eclampsia was considerably higher in women under 20 than in older groups. Ojengbede (1987) reported a higher incidence of pregnancy induced hypertension among the younger women. (Prasad, 1983; Mishra and Dhawan, 1986; Sukanch, 1986; Sarkar, 1986; WHO, 1987; Padte, 1988 and Adedoyin 1989) have reported similar observations regarding maternal age and hypertensive disorders. All the authors agreed that inadequate prenatal care to be the major cause for the higher rate of hypertensive disorders among teenage mothers.

Nutritional anaemia has been recognized as public health problem in India. It has been reported that 60-80% of pregnant women suffer from anaemia in different regions of the country. Nutritional anaemia due to iron deficiency and folate deficiency are found to be more common among adolescent mothers (Figueroa, 1988). It is considered as one of the most frequently encountered nutritional problems of pregnancy and contributes significantly towards maternal mortality and morbidity (Nutrition News, 1989; Ingle, 1992) and that birth weight may be adversely affected in anaemic mothers (ICMR Project Report, 1985-86; Ingle, 1992).

It has been demonstrated that the mean birth weight of newborns delivered by women having haemoglobin level above 10.5 g % was 2.6 kg., while those having less than 6.5 g % was 2.4 kg. only. Since 70% of deaths occur in children with birth weight below 2.5 kg. anaemia can be a significant contributor for perinatal mortality and premature deaths (Reinhardt, 1980; Annual Report, NIN, 1981-C; Prema et al 1981; Annual Report, NIN, 1982-B; Prema 1984; Bhatia and
Tyagi 1984; Tyagi et al, 1985; Agarwal et al 1988; Flores 1990). However Murphy et al (1986) observed that haemoglobin levels in the first and second trimesters of pregnancy had no significant association with the outcome of pregnancy and also contradicting the earlier studies, Annual Report, NIN (1983-B) reported the incidence of low birth weight to be same in all haemoglobin levels in the low income group.

Leader et al (1981) stated that haemoglobin concentration of a mother is a poor index of iron status since haemoglobin values vary in accordance with changes in blood volume which occurs during pregnancy. They suggested that transferrin saturation may be a better index for true iron value during pregnancy.

Role of malaria in the pathogenesis in pregnancy anaemia and the fact that income is inversely related to anaemia was reported by Reinhardt (1980). Anaemia was observed to be higher among the younger mothers than older (Padte, 1988; Brabin and Brabin, 1992).

Maternal age and parity are reported to influence the size of the baby at birth (Kramer, 1987). Parity has been defined as the number of previous pregnancies which resulted in either live births or still births after 28 weeks of gestation and categorized into three groups primiparous, low parity multiparous and high parity multiparous. High parity was defined as third or higher order births to mothers under age 20 and fourth or higher order births to mothers age 20 and over.

In general, primiparous women give birth to infants who are smaller than those of multiparous women. It is well accepted that the birth weights of the first baby is lower than that of subsequent siblings. This has been documented by numerous researchers. (Reinhardt, 1980; Annual Report, NIN, 1983-C; Ramankutty et al, 1983; Kramer, 1987; Prentice et al, 1987; Gopalan, 1989;
Sweeney, 1989). However the influence of multiparity on birth weights and subsequent growth of infants still remains equivocal.

Continuous increase in birth weight up to fifth para was reported by (Rajalakshmi, 1980; Ramankutty et al, 1983; Simon et al, 1990). Seidman et al (1988) in their recent study, observed a significant decrease in the incidence of SGA babies in multiparas (3.6%) as against to primiparous (5.8%). They found that this difference was independent of maternal age and there was no increase in obstetric complications or neonatal morbidity and also biochemical parameters. Rajalakshmi (1980) observed a direct relationship between parity and maternal weight. Mortality rate was higher in para 1 and para 2 and the risk increased with each additional birth. This observation was found to be independent of age (Walker et al; Annual Report, NIN, 1983-C).

In contrast to the above findings Horon et al (1983) and Santelli et al (1990) found no significant difference between birth weights of infants born to primiparous and multiparous.

It was also reported in the Annual Report NIN (1983-B) that incidence of B-Complex deficiency signs especially angular stomatitis and glossitis were more severe in higher parity.

Maternal Nutritional Status

Anthropometric indices of nutritional status during pregnancy and their relation to foetal weight have been a matter of considerable interest to obstetricians, nutritionists and public health workers. Many of these indices have been used as markers of intra-uterine malnutrition and low birth weight.

Two most frequently measured parameters of maternal size or physical stature of a mother are weight and height. Maternal size is influenced by genetic
characteristics. However, environmental influences such as nutrition and infection/diseases during the growth period also play an important role in determining ultimate body size of a woman.

Maternal weight, height and weight for height are used frequently as indirect measures of nutritional status. The weight for height ratio used most frequently in the analysis of these data is the Body Mass Index (BMI), which is calculated from weight and height. BMI measurements generally correlate well with more accurate measurements of body fat content such as body density of total body water (Garrow, 1983).

Infant birth weight has been correlated with maternal height, weight and weight for height ratios (Frydman, 1980; Annual Report, NIN, 1982-C; Bhatia et al, 1983; Frisancho et al, 1984; Bhatia and Tyagi, 1984-A; Bhatia et al, 1985; Dougherty and Jones, 1985; Tyagi et al, 1985; ICMR Project Report, 1985-86; Kramer, 1987; Bhatia et al, 1988; Maso et al, 1988; Scholl et al, 1990). Agarwal et al (1988) demonstrated that incidence of LBW babies was 12.9% when mother’s weight was more than 55 kg. and 42.9% when they weighed less than 35 kg.

Height of a mother seems to be an equally important factor affecting the birth of a newborn. Height measurements have special place as an index of socio-economic development in developing societies. Ramankutty et al (1983) found a consistent linear increase in birth weight with increase in height of mothers from 130 to 170+ cms. Bhargava et al (1983) reported the highest correlation coefficients of maternal height to the birth weight of an infant.

Weight corresponding to a specific height is an accepted index for expressing physical stature. The association between low weight for height at the time of conception and poor outcome of pregnancy has been demonstrated by
several scientists. Their studies indicated that incidence of low birth weight babies was higher in severely underweight mothers as compared to a control group of women who had normal weight for height.

Although maternal stature seems to be an important variable affecting birth weight, it must be recognized that in poor countries, chronic undernutrition may be responsible for small stature.

Various researchers have also demonstrated a direct relationship between stunting of mothers and the occurrence of low birth weight infants (Bhargava et al, 1983; Ramankutty et al, 1983). It is known that infants who have a poor start in life never fully recover from their initial handicap (Desai and Cunningham, 1986; Khatua et al, 1987). Thus, stunted children with impaired learning abilities end up as stunted adults with low levels of productivity, educational attainment and resourcefulness and earn low incomes. Thus they continue to be enmeshed in the poverty trap, and so are unable to feed their children adequately. This vicious cycle continues for generations (Gopalan, 1987). These findings emphasized that it is not sufficient to take care of diet and nutritional status of women only during pregnancy and that nutritional preparation for pregnancy begins at infancy, perhaps even during foetal life.

Bhatia and Tyagi (1984) found that maternal height was significantly correlated with birth weight even after controlling mother's weight, haemoglobin and gestation. They found a coefficient of 10.66g for unit change in maternal height. Bhargava et al (1983) reported that increasing maternal weight for same height was found to be better correlated with birth weights rather than increasing maternal height for the same weight.

Both maternal weight for height ratio index and the dietary intakes were found to influence foetal growth as observed by Bhatia et al (1983). Tyagi et al
(1985) found more than 53 percent incidence of LBW babies in short mothers (<145 cm). (Reinhardt, 1980; Raman, 1981) found an increase in birth weight of only 100g between mother of height < 145 cm and > 160 cm.

The National Nutrition Monitoring Bureau in Hyderabad, India, in their study on dietary, nutritional and anthropometric status observed that the height and weight of population faithfully reflected the socio-economic gradient. The difference in height of the children from high and low economic group was approximately 8-10cms and in case of adults, it was 5-6 cms. A similar difference was observed in body weight by Gopalan (1987).

Frisancho et al (1984) also observed that the contribution of the placenta to birth weight was much greater among the teenagers who had completed their growth. The same has been schematically explained (Fig. 6).

Though maternal weight at term is appropriate for height, teen mothers have smaller babies than adult women do (Reinhardt, 1980; Frydman, 1980; Dougherty and Jones, 1982; McAnarney, 1985; ICMR Project Report, 1985-86; Haiek and Lederman, 1988; Ravindra et al, 1988).

A difference in weight and height between rural and urban mothers was reported in the Annual Report, NIN (1991-92). A study by Kleinman (1990) designed to determine whether there is an independent effect of maternal height on total weight gain, it was observed that there was no evidence that short women had an increased risk of low weight gain.

Bhargava et al (1983) stated that, using maternal size (weight for height), expected birth weight of an infant can be predicted and thus small for date babies can be identified better (Table 2).
Table 2: Expected mean birth weights of term babies by maternal size.

<table>
<thead>
<tr>
<th>Maternal height and weight</th>
<th>Expected approx. weight at term (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tall and Healthy mothers. (Height &gt;= 155 cm, weight &gt; 55 Kg)</td>
<td>3200 ± 475</td>
</tr>
<tr>
<td>Average mothers. (Height 145 -- 154 cm, weight 45 -- 49 Kg)</td>
<td>2700 ± 425</td>
</tr>
<tr>
<td>Short and light mothers. (Height &lt; 145 cm, weight &lt; 45 Kg)</td>
<td>2350 ± 400</td>
</tr>
</tbody>
</table>

Fig. 6: Schematization of the determinants of new born weight among infants born to still growing and fully grown teenagers.

Source: Frisancho et al, 1984
Expected birth weight of an infant of small sized mother would be lesser than that of larger sized mother. Hence a low birth weight infant of larger mother may be at higher risk than the infant with the same birth weight delivered to a small size mother. Therefore they suggested that recording of maternal height and weight soon after delivery should be included in routine list of information collected by the Pediatric House Officer when assessing a neonate.

There has also been a consistent relationship between pre-pregnancy weight and birth weight among mothers of the same height. The short stunted and underweight mothers have low birth weight babies. Further the prevalence of low birth weight babies and premature births is more in women having lower pre-pregnancy weight (Reinhardt, 1980; Tripathi et al, 1987; Agarwal et al, 1988).

Total weight change during pregnancy can vary from a weight loss to a gain of more than 30 kg (66 lbs.). This wide variation in gain among pregnant women appears to be attributable to several physiologic and environment factors. Certain maternal characteristics an health habits may also exert an influence. Rajalakshmi (1980) and Annual Report, NIN (1981-B) have indicated that there was a fall in the body weight during the first trimester of pregnancy due to reduced food intake as a result of nausea and vomiting.

Body Mass Index (BMI) expressed as a ratio of weight (Kg) to height (m) is considered as a good indicator of nutritional status in adults. The weight for height status of the mother before conception is frequently used as a marker for the mother’s nutritional state before pregnancy. A low weight for height is assumed to reflect marginal tissue reserves, whereas a high value is believed to be indicative of excessive reserves. Kleinman (1990) presented the distribution of total weight gains according to four BMI groups: <1.98, 1.98 to 2.60, 2.61 to 2.90 and >2.90 i.e. low, moderate, high and very high weight for height.
Mothers with chronic energy deficiency had comparatively lower BMI (Annual Report, NIN, 1991-92) and also Rural and Urban differences in BMI was observed. They found no difference in mean heights across BMI groups. The birthweights were highly correlated with the BMI status of the mother (Annual Report, NIN, 1991-92).

It was also reported by Goranov et al (1990) that body weight of the newborns of underage mothers was 328 g. lower (P<0.0001) than the mean body mass of the whole population.

Significantly high correlation was observed between weights and BMI but height remained the same (Raman, 1990; Annual Report, NIN, 1991-92). The study indicated that normal BMI of pregnant women is associated with better pregnancy outcome and helped overcome the risk of low birth weight (Abrams & Laros, 1986). Therefore, efforts are needed to improve the BMI status of women in the reproductive age. Hediger et al (1990) observed that with excessive pre-pregnancy body mass index ( >1.79 - 1.93 ) at term, the birth weight did not further improve. Body Mass Index was found to be better indicator of isolating risk groups than weight for height alone (Annual Report, NIN, 1983-A). Stanley et al (1984) studied the weight and stature of 1,601 teenage girls. He reported that high pregnancy weight gains were not associated with greater statural growth. Increases in both stature and weight diminished with increasing years since menarche and were small overall.

Low pre-pregnancy weight and low gestational weight gain are more common in teens than in adults (Meserole and Coworkers, 1984; Figueroa et al, 1988; Haiek and Lederman, 1989; Hediger, 1989).
Scholl et al (1989) found pregnancy weight gain to be associated with other factors such as mother's ethnicity, length of gestation, parity and presence of pregnancy related hypertension.

Several reports have brought about positive relation of prenatal weight gain to foetal weight. Small maternal weight gain may cause small foetal weight. It is now a well established fact that prenatal weight is one of the important determinants affecting birth weights of infants (Frydman et al, 1980; Picon et al, 1982; Horon et al, 1983; Mc Anarney, 1985; ICMR Project Report, 1985-86; Brown et al, 1986; Mitchell and Learner, 1987; Halek and Lederman 1988; Rosso, 1990; Schneik et al, 1990). However, there is no unanimity regarding "ideal" or "optimal" weight gain during pregnancy. Generally one kg. of maternal weight gain leads to an increment of 20-25 gms. in the birth weight. Or in other words, a weekly weight gain of less than 0.2 kg. more than doubles the likelihood of the incidence of LBW (Ebrahim, 1983).

It is believed that optimum prenatal weight gain for favorable outcome of pregnancy depends on pre-pregnancy weight status of the mothers. Brown et al (1986) in a study of women from low socio-economic status reported that influence of prenatal weight gain on birth weight of infants varied according to pre-pregnancy weight status. They observed that prenatal weight gain was the most influential factor affecting birth weight among normal and over weight mothers. Similar was the result observed by (Gormican et al, 1980; Rajalakshmi, 1980; Brown et al, 1981; Annual Report, NIN, 1983-A; Frisancho, 1983; Garn and Petzold, 1983; Frisancho et al, 1984; Verma, 1984; Loris et al, 1985; Abrams and Laros, 1986; Mitchell and Learner, 1987; Simon and Mc Anarney, 1988; Panel Report, 1990).

Picon and coworkers (1982) reported in normal weight women that a prenatal weight gain of less than 15 lbs. resulted in infants having significantly
lower birth weight than women whose weight gain was more than 15 lbs. (Verma, 1984; Tripathi et al, 1987; Scholl et al, 1988; Ravindra, 1989; Panel Report, 1990) also revealed similar results. However, it is be possible that when weight gain is below a certain critical level, birth weight may be adversely affected (Mc Anarney, 1985).

Gam and Petzold (1983), Hediger (1989) contradicted the observations made by other authors and are of the opinion that birth weight did not improve with excessive weight gains among adolescents.

The difference of opinion regarding the pregnancy weight gain and birth weight among adolescents may be explained by the diverse factors such as incomplete maternal growth, reproductive immaturity, diminished maternal body size, nutritional deficiencies, socio-economic and behavioral factors and maternal emotional stress. It may be summarized from the available literature that weight gain during pregnancy must be based on pre-pregnancy weight status and that adequate weight gain is of critical importance to women beginning pregnancy underweight. One more reason is that in rapidly growing teenagers the nutritional requirements of pregnancy may be greater than those of older women, and that this increased requirements competes with the growth needs of the foetus.

Over the past century, there have been substantial changes in recommendations made to women about weight gain during pregnancy. In the sixteenth, seventeenth and eighteenth centuries, much emphasis was placed on the maternal diet since the mother was known to be the only source of nutrients for the foetus (Rosso and Cramoy, 1979). In the nineteenth century, the idea that pregnant women should not overeat became a recurrent theme. Overeating was believed to be a cause of large babies, and, as a consequence, more difficult labours.
Apart from weight gain, the skinfold measurements are also used to assess the mother's nutritional status.

Triceps skinfold thickness of the mothers is expressed as a percentage of normal values. According to the variable, which indicates the amount of adipose tissue in the upper arm, fat stores are markedly below normal values in the population studied by Reinhardt (1980). It was also observed by the same author that this measurement was lower in primiparous mothers but not significant.

Changes in skinfold thickness have been widely used to estimate changes in the fat content of pregnant women. Skinfold thickness measurements suggest that more maternal fat is accumulated centrally than peripherally. Skinfold thickness can be measured quickly with relatively inexpensive equipment. As one early researcher cautioned, however skinfold measurements are relatively inaccurate and a high degree of standardization is required to obtain reliable comparisons even with one observer (Taggert et al, 1967). Proper use requires extensive training and monitoring to consistently achieve reproducible measurements.

Longitudinal studies of skinfold thickness in pregnant women suggest that skinfold thickness in late pregnancy may be increased by water retention. Therefore, an observed increase in skinfold thickness may not indicate an increase in body fat. Especially during late pregnancy, skinfold thickness measurements may be less indicative of body fat content.

In several studies, skinfold thickness values themselves have been used without calculating body fat content. In this approach, investigators used either individual skinfold thicknesses (Frisancho et al, 1977; Viegas et al, 1987; Maso et al, 1988) or a sum of several different skinfold thicknesses (Arroyo et al, 1978; Prentice et al, 1981; Lawrence et al, 1984) but they did not assume that all the
measured change reflects changes in body fat. This approach may be conceptually more justifiable than relating skinfold thicknesses to body fat. Furthermore, by combining skinfold thickness measurements with arm circumference measurements, it is possible to estimate arm muscle area, which reflects the amount of lean tissue. This could be of value, since it is not known whether maternal fat or lean tissue increments are more important for foetal growth. Frisancho et al (1977) observed that maternal arm fat was related to infant fatness, but not birth weight, whereas arm muscle area was related to infant length. In contrast, Maso et al (1988) observed that arm fat area and arm circumference changes between weeks 22 and 32 of gestation were correlated with birth weight, but arm muscle area was not. Contradicting the studies by Frisancho et al (1977) and Maso et al (1988), Briend Andre (1980) was of the opinion that the morphology of the new born infants was largely independent of maternal mid upper arm circumference suggesting that the main limiting factor of foetal growth was not insufficiency of maternal nutritional reserves.

Thus skinfold thicknesses have been used to describe normal body fat changes throughout gestation, to determine whether skinfold thickness is associated with foetal outcome or with supplementation in undernourished women, to identify women with unusually small or large changes in body fat during pregnancy, and to estimate the initial body fat content.

A study by Maso et al (1988) has provided some information on changes in skinfold thickness that occur very early in pregnancy. The data indicated that body weight increased by 2 Kg. and body fat increased by 1.54 Kg. between the pre-pregnancy measurement and the seventh week of pregnancy. Thus, the study supported the possibility that maternal fat may already be increased above pre-pregnancy levels. Triceps skinfold thickness was lower in primiparous mothers but this was not significant. Low triceps skinfold was associated with lower haemoglobin level (Reinhardt 1980).
Mid arm circumference is a good and a very sensitive indicator of muscle mass and has been used as a parameter for assessment of nutritional status during pregnancy. Tibrewala and Shah (1978) and Stephen et al (1979) have shown that the maternal mid arm circumference is directly correlated with maternal weight and they can be used to assess maternal nutritional status during pregnancy.

Devi (1984) found a difference of 160 g. in birth weight of offsprings born to mothers with mid arm circumference below and above 23 cms. Agarwal et al (1988) have suggested weight and mid arm values for detecting undernutrition. Thus anthropometrics may be useful in predicting those teens at highest risk of bearing LBW infants.

Pregnancy and lactation are the two stages in life when nutritional needs of the mothers increase. To a large extent, the mother has the responsibility of supporting intra-uterine growth of the foetus, and later on nursing the infant for the first few months of life. Various attempts have been made to estimate the additional requirements during pregnancy. Among all the nutrients energy and protein intake has been related to obstetric performance i.e. birth weight.

Naismith (1985) suggested the factorial method for recommending the optimal dietary intake of nutrients during pregnancy. The procedure is based on the nutrients that are required for the synthesis of new tissues in the mother's own body and in the foetus and placenta as well as for augmenting maternal stores. These values are then divided by the duration of pregnancy to give the additional daily requirements that has to be added to the diet of non pregnant woman.

Further Naismith (1985) stated that from early pregnancy the balance of nutrient utilization is reset in favour of anabolism. A more economical use of nutrients is achieved by two ways, firstly by increasing the proportion of the
ingested nutrient that is absorbed, and secondly, by suppressing their catabolism. These metabolic changes are induced by a variety of hormones secreted by the foeto-placental unit. Nutrients supplied for foetal growth are further augmented by the active mobilization of maternal reserves, thus the foetus is assured its food supply.

The Indian Council of Medical Research (1991) has recommended 300 Calories and 14 g of protein in addition to daily requirement of non gravid women in India. The FAO/WHO expert group has also suggested similar increments in daily diet (Leader et al, 1981; Rosso 1990).

Durnin et al (1985) conducted a well planned diet survey to determine energy intakes and energy expenditure of healthy pregnant women and to estimate additional requirements of energy which would ensure optimum outcome of pregnancy. They concluded that additional 50-100 Calories/day for first 34-36 weeks and 200 to 300 Calories/day for the last few weeks was enough for normal outcome of pregnancy. They attributed these comparatively low increments in dietary energy to a fall in basal metabolic rate during early stages of pregnancy and reduced physical activities in the later stage of pregnancy. They found that mean increase in energy consumption from the beginning up to 34 to 36 weeks was only 50 Calories/day and in the last few weeks it was around 300 kcal/day. This resulted in optimum weight gain during pregnancy and produced normal healthy infants. (Frydman, 1980; Bhatia et al, 1983; Rosso, 1990) observed similar results in their study.

Adolescent mothers who have not completed their own physical growth may need a still higher supply of nutrients to support normal growth of the foetus during pregnancy (Scholl et al, 1990). Review of the available literature indicates that outcome of pregnancy depends on the extent of maternal nutritional adequacy (Bhatia et al, 1983; Figueroa et al, 1988; Rosso, 1990; Kadam and Devi, 1992).
Thus, it would appear desirable for a women to augment food consumption during pregnancy. The additional food requirement has been quantified by using chemical analysis of bodies of foetuses and of placentas as a basis (Naismith, 1985). These theoretical calculation do not really account for changes in the maternal metabolism, especially in the duration of more economical nutrient utilization in the face of under nutrition (Naismith, 1985). Therefore it is recommended that it may be more practicable to examine the effect of different degree of maternal undernutrition on reproductive performance and more importantly to relate birth weights to relative adequacy of the diet. Further Naismith (1985) has emphasized that in most surveys, which have shown positive correlation between maternal weight gain during pregnancy with birth weights, rarely was the dietary component examined separately from other factors known to affect birth weight. Such an exercise would be necessary to determine appropriate modes of nutritional intervention if birth weight must be raised as one must create favorable environment for later development. Controversial statement is reported by Dougherty and Jones (1982) that improving maternal nutrition would not completely eliminate the problem of low birth weight. It appears that environmental factors such as morbidity and physical activity may be responsible for the observation made by this author.

Moderate undernutrition is found commonly in less developed countries. Chronic, mild or moderate undernutrition of long duration is a common feature of these parts of the world, which ultimately results in stunting i.e. low height and weight of women. In such conditions the body seems to adjust to such subnormal nutritional intakes without exhibiting classical signs of severe nutrient deficiencies.

In Bangladesh, Chaudhary (1985) observed that expenditure on food per day and the amount of time worked in productive activity were important determinants of nutrient intakes and their adequacy for pregnant and lactating women. The most important factor is the lack of resources especially for those
who live below the poverty level. No obvious/drastic effect of moderate undernutrition on pregnancy outcome has been reported in such circumstances. Earlier studies have concluded that nutritional level required to precipitate pregnancy complications might be lower than 1500 kcal/day. Similar were the observations made by Prentice (1980). It has been suggested that malnutrition of a degree sufficient to affect reproductive performance usually occurs with poverty and limited resources (Gormican et al, 1980; Figueroa et al, 1988).

Teenage Pregnancy and Infant and Maternal Mortality

The offspring of teenage mothers have long been known to be at increased risk of infant mortality largely because of their high prevalence of low birth weight (less than 2500 gms) (Dougherty and Jones, 1982; ICMR Project Report, 1985-86). Neonatal mortality declined steadily with increasing maternal age. Prevention of neonatal mortality and post neonatal mortality among babies born to teenagers depend on preventing low birth weight. These observations were agreed upon by (McCormick et al, 1984; Harrison, 1985; Khan, 1986; Kwast, 1986; Mishra and Dhawan, 1986; Walker, 1986; Ojengbede, 1987; Friede et al, 1987; Faveau, 1988; Fortney, 1988; Koenig, 1988; Padte, 1988; Rahman et al, 1989; Rosso, 1990; Goranov et al, 1990) who observed no difference in the perinatal infant mortality between the two groups but observed almost three fold higher mortality in newborn upto one year of age in the younger group. Refcroft and Kessler (1980) also found no difference between the two groups as far as perinatal mortality was concerned. Obstructed labour and toxaemia were the major cause of mortality among young women and major cause of neonatal mortality was birth injury and tetanus as reported by Rahman et al (1987). Similar were the factors responsible for maternal mortality as reported by Mishra and Dhawan (1986), but in addition, they have reported haemorrhage, ectopic pregnancy, pulmonary embolus and sepsis also as associated causes for higher mortality among
younger women (Khan, 1986; Kwast, 1986). Goranov et al (1990) opines that malformations were the most frequent cause for postnatal mortality. Whatever may be the cause, the mortality rates, perinatal, neonatal and infant were respectively 65.3, 57.7 and 94.5 and high ratio of still births (29.3 per 1000 deliveries) in the high risk families according to the ICMR Project Report (1985-86).

Anaemia still remains the major nutritional problem associated with maternal and perinatal mortality and morbidity. Poverty, ignorance, non-availability or failure to utilize available medical facilities have been shown to be associated with maternal anaemia, maternal and perinatal morbidity and mortality (Annual Report, NIN, 1981; Prema et al, 1981; Prema, 1984).

Antenatal Care

Antenatal care plays an important role in ensuring optimal outcome of pregnancy. Kapoor et al (1985) studied the effect of antenatal care on perinatal mortality and found that antenatal care significantly reduced the incidence of low birth weight, still births, neonatal and perinatal mortality though it did not show any significant influence on mean birth weight. The low birth weight rate for TAPP (Teenage Pregnancy Programme) participants was statistically significant and strongly associated than was race age, parity or gender (Scholl, 1987; Korenbroot, 1989). Fewer prenatal visits accounted for the largest proportion of low birth weights as reported by Slap and Schwartz (1989). High risk of young multi gravidae aged 17-19 were reported by Harrison (1989) who had limited access to prenatal care and late arrival at hospital.

The outcome of pregnancy in adolescent mothers compares unfavourably with the outcome in more mature women. The number of low birth weight babies (<2500 g) is considerably higher in mothers less than 19 years of age. This
suggests a downward shift in mean birth weight, a change that usually indicates unfavorable maternal conditions during gestation. Perinatal mortality is strongly associated with low birth weight babies and accompanied by higher death rates (NAS, 1990). It is also indicated that, in addition to delivering smaller infants with a higher risk of death in the neonatal period, teenage mothers have a higher incidence of premature delivery, caesarian sections due to cephalopelvic disproportion and toxaemia.

Improvement of maternal and foetal health and nutrition has been a public health goal since the beginning of organized medicine. Attitudes and beliefs regarding prenatal care and nutrition have changed. Furthermore, socio-economic status of the population has improved along with technological advancements. These changes undoubtedly have influenced the nutrition and health of women entering and during their pregnancies, as well as both maternal and foetal outcomes.

A schematic summary of determinants, consequences and effect modifiers of pregnancy outcome has been presented in Fig. 7.

So far what has been discussed in this chapter reflects that teenage pregnancy is dominating in the low socio-economic class for various reasons. These pregnancies are at great risk both for mother and infant. Thus prime importance must be given to the non formal education for these adolescent school dropouts. Education component must include lessons on postponing the conception to adulthood (beyond 20 years of age) and nutritional care of adolescent pregnant girls. With this background it should be possible to reduce the health and nutritional risk factors for these girls.
MATERNAL FACTORS
Nutritional (body mass index or relative weight, height, lean body mass fat)
Sociodemographic (age, parity, ethnic background, socioeconomic status)
Behavioral (attitudes, cigarettes, alcohol)

NUTRITIONAL INTERVENTIONS
Nutritional counselling, supplementation
Health education

GESTATIONAL WEIGHT GAIN (OVERALL AND PATTERN)
Mother
Lean body mass
Fat
Total body water
Products of Conception
Fetus

SHORT-TERM HEALTH OUTCOMES
Mother
Mortality
Complication of pregnancy, labor and delivery
Lactation performance
Obesity
Fetus, Child
Mortality
Fetal growth (birth weight, length, head circumference)
Gestational duration
Spontaneous abortion
Congenital anomalies

LONGER-TERM HEALTH OUTCOMES
Mother
Obesity
Child
Somatic growth
Neurocognitive development

--- indicates possible causal influences
|--- denotes possible modification of effect indicated by arrow on which it abuts

Fig. 7 Determinants, consequences, and effect modifiers of pregnancy outcome.